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NATIONAL DAM SAFETY PROGRAM. SPRING LAKE DAM (MO 30725), MISSIS-ETC(U)

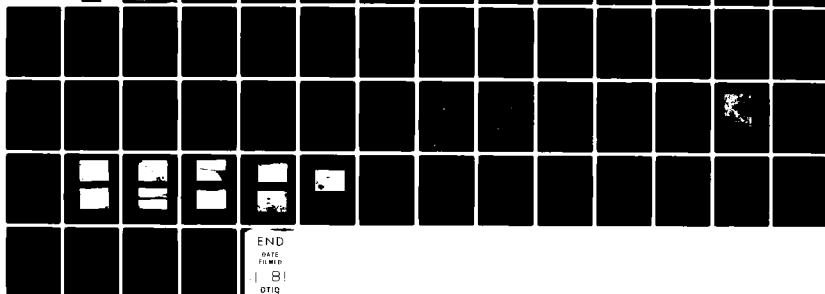
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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

1. PROJECT NAME
2. PROJECT NUMBER
3. PROJECT LOCATION

4. PROJECT DESCRIPTION

5. PROJECT STATUS

6. PROJECT OWNER

7. PROJECT CONTACT

10-10-10

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		



DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

SUBJECT: Spring Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Spring Lake Dam (MO 30725).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St Louis District as a result of the application of the following criteria:

- a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.
- b. Overtopping of the dam could result in failure of the dam.
- c. Dam failure significantly increases the hazard to loss of life downstream.

SIGNED

2 OCT 1980

SUBMITTED BY: _____

Chief, Engineering Division

Date

SIGNED

APPROVED BY: _____

Colonel, CE, District Engineer

6 OCT 1980

Date

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SPRING LAKE DAM
Washington County, Missouri
Missouri Inventory No. 30725

Phase I Inspection Report
National Dam Safety Program

Prepared by

Woodward-Clyde Consultants
Chicago, Illinois

Under Direction of
St Louis District, Corps of Engineers

for
Governor of Missouri
September 1980

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Spring Lake Dam
State Located	Missouri
County Located	Washington
Stream	Unnamed Tributary of Little Indian Creek
Date of Inspection	16 July 1980

Spring Lake Dam, Missouri Inventory Number 30725, was inspected by Richard Berggreen (engineering geologist), Leonard Krazynski (geotechnical engineer), John Seymour (geotechnical engineer) and Sean Tseng (hydrologist). The dam is an earthen dam used for recreational purposes.

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspections of Dams". These guidelines were developed by the Chief of Engineers, US Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. They are intended to provide an expeditious identification, based on available data and a visual inspection, of those dams which may pose hazards to human life or property. In view of the limited nature of the study, no assurance can be given that all deficiencies have been identified.

The St Louis District, Corps of Engineers, has classified this dam as a high hazard; we concur with this classification. The SLD estimated damage zone extends approximately five mi downstream of this dam. Within this zone are at least eight occupied structures. Overtopping and failure of this dam could cause loss of life and property.

Spring Lake Dam is in the small size classification based on its maximum height of 27 ft and its reservoir storage volume of 107 ac-ft.

Our inspection and evaluation indicate the dam is in fair condition. This evaluation is based on hydrologic analyses that indicate the spillway will pass only 19 percent of the Probable Maximum Flood (PMF) without overtopping the dam. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The

hydrologic analyses also indicates that the dam will pass the 10 percent probability-of-occurrence flood (10-yr flood) but that it will not pass the 1 percent probability-of-occurrence flood (100-yr flood). One slump was noted on the face of the embankment, and two low flow seepage areas were found, neither of which were transporting soil particles.

Erosion of the downstream channel is occurring and at least two trees large enough to restrict flood flows are located in the downstream channel.

Based on our inspection and hydraulic/hydrologic analyses, it is recommended that a detailed hydrologic analysis be undertaken on a high priority basis. The analyses should establish a design height of dam and spillway capacity required to be able to pass 100 percent of the PMF without overtopping of the dam. This has been established based upon the fact that, for the present conditions, overtopping for nearly 6 hours by the 100 percent PMF could develop into a virtual breach of the dam with consequent release of most of the reservoir contents in a fairly short time. Such detailed studies could well show that it may be possible to construct a spillway large enough to pass less than 100 percent of the PMF and thereby reduce the depth and time of overtopping to the point where breaching and release of reservoir contents would not occur.

It is also recommended that the following items be investigated as soon as practical:

1. Reconstruction of the spillway discharge channel to a point downstream where the dam will not be jeopardized by channel erosion.
2. Removal of possible flow obstructions from the downstream channel such as large trees.
3. Clearing of the spillway approach of sediments and obstructions to flow and prevent further accumulation of debris and sediments.
4. Performance of seepage and stability analyses in accordance with the requirements of the guidelines.
5. The feasibility of a warning system to notify downstream residents should potentially hazardous conditions develop during periods of heavy precipitation.

6. Implementation of a periodic inspection and maintenance program for this facility. Records should be kept of all inspections and consequent maintenance. This program should include but not be limited to the following:

- a. Monitoring of slumps on the dam face and settling of the dam crest,
- b. Checking the amount and turbidity of seepage,
- c. Maintaining an erosion control system,
- d. Periodically cleaning sediments that inhibit outflow,
- e. Maintaining the spillway discharge channel and dam slopes free of trees and bushes.

All analyses, inspection, maintenance and modifications to the dam should be done under the guidance of an engineer experienced in the design and construction of earthen dams.

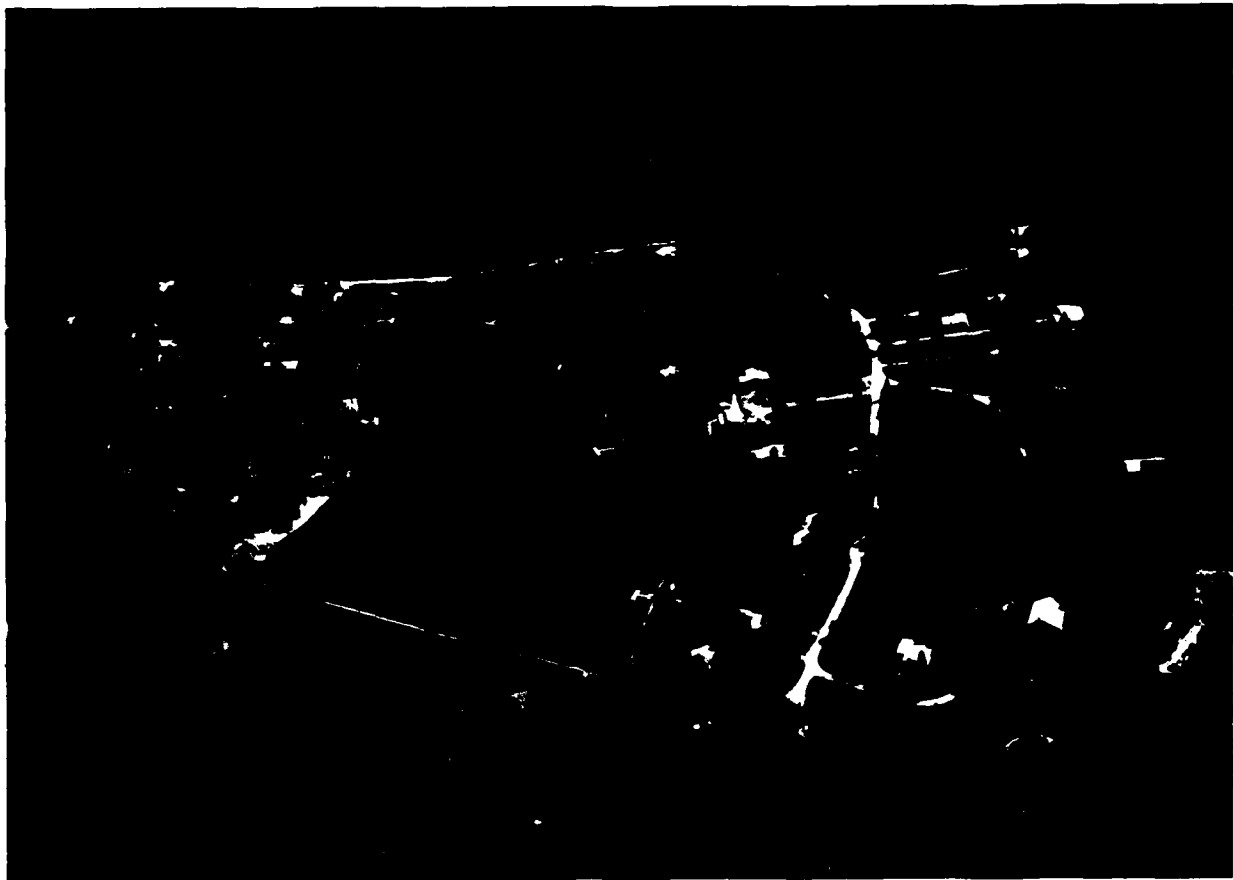
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Richard G. Berggreen
Registered Geologist



Leonard K. Krazynski, P.E.
Vice President



OVERVIEW

SPRING LAKE DAM

MISSOURI INVENTORY NO. 30725

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
SPRING LAKE DAM - MISSOURI NO. 30725
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3A.	Plan and Sections of Dam and Spillway
3B.	Plan of Spillway Trough
4.	Regional Geologic Map

APPENDICES

A	Figure A-1: Photo Location Sketch
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Photographs

1. Spring Lake Dam alignment, spillway, downstream channel and hillslope erosion; looking northwest.
2. Downstream hazards below Spring Lake Dam.
3. Two inch siphon tubes.
4. Broad-crested weir with 4 inch pipes, trapezoidal spill area, debris and fish fence; looking northeast with dam to the right.
5. Rectangular flow channel starts beneath the footbridge, broad-crested weir to the right; looking northwest.
6. Downstream face of dam indicating size and type of vegetation. Swampy area in center of photo; looking west.
7. Upstream face of dam showing water levels riprap and crest condition; looking southeast.
8. Gullying to bedrock downstream of the discharge and of the 5.0 ft wide low-level flow channel.
9. Downstream channel of Spring Lake Dam showing erosion and vegetation; looking northeast.

B	Hydraulic/Hydrologic Data and Analyses
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**PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
SPRING LAKE DAM, MISSOURI ID. NO. 30725**

**SECTION I
PROJECT INFORMATION**

1.1 General

- a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of the Spring Lake Dam, Missouri Inventory Number 30725.
- b. **Purpose of investigation.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted" (Chapter 3, Recommended Guidelines for Safety Inspection of Dams).
- c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams", Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design National Program for Inspection of Non-Federal Dams", by the Office of Chief of Engineers, Department of the Army; and "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams," prepared by the St Louis District, Corps of Engineers (SLD). These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of Project

- a. Description of dam and appurtenances. Spring Lake Dam is an earthen dam (Photo 1; Appendix A). The spillway, located at the left abutment, consists of a shallow trapezoidal spill area, a broad-crested weir and a rectangular low-level concrete-lined drainage trough at its far left side. The entire concrete spillway is 48.3 ft wide. The bottom of the low-level trough is 1.33 ft below the crest of the trapezoidal spillway, which is 1.20 ft below the nearest edge of the dam crest. Two 2-in. inside diameter plastic siphon pipes are installed through the dam crest to lower the lake level. No mechanically operated control structures for regulating spillway flows are present. A series of four in. pipes through the broad-crested weir were originally intended to maintain the lake level slightly below spillway crest, however, the lower lying drainage trough now controls the reservoir level (Photos 4 and 5).
- b. Location. The dam is located on an unnamed tributary of Little Indian Creek, approximately two mi south-southeast of the town of Richwoods in Washington County, Missouri, Section 9, T39N, R2E, on USGS Richwoods NE 7.5 min quadrangle map.
- c. Size classification. The dam is classified as small due to its 27 ft height and 107 ac-ft storage capacity. A small dam is one which is 25 to 40 ft high and has a storage capacity of 50 to 1000 ac-ft.
- d. Hazard classification. The St Louis District, Corps of Engineers has classified this dam a high hazard dam; we concur with this classification. The SLD estimated damage zone extends approximately five miles downstream. Located in this zone are at least eight dwellings, a road and a mobile home. Some of these structures which are shown in Photo 2 one located about one mi downstream of the dam. Loss of life and property could be large in the event of overtopping and failure of this dam.
- e. Ownership. The dam is reportedly owned by Spring Lake Subdivision Association, herein to be called the "Association." We were advised correspondence is to be directed to Mr John Harsh, 2261 Lynch, Granite City, Illinois 62040.

- f. Purpose of dam. The reservoir created by the dam is used primarily for recreation purposes.
- g. Design and construction history. No design or construction reports were found for Spring Lake Dam.

All design and construction information has been obtained from interviews with Mr John Harsh, President of the Spring Lake Subdivision Board of Trustees. Mr Harsh indicated that the dam was built in 1952 by Mr Paul Shy of Sunset School Road, Sunset Lake, near Desoto, Missouri. A road ran across the original dam crest and spillway. The original spillway was a four in. thick concrete pad. The dam crest was raised 18 in. around 1954.

In 1975, the lake level was lowered 8 to 10 ft, using two 2-in. inside diameter siphon plastic tubes which remain in place and pass through the dam about six in. below the crest (Photo 3). The reservoir banks were then deepened four to six ft using a bulldozer, to inhibit shallow water algae growth.

In 1976 the spillway was redone by excavating the northwest abutment down to bedrock and constructing a concrete wall to the present height and adding a 43.3 ft wide, broad-crested weir. The concrete spillway slab contains ten 4-in. diameter pipes (Photo 4).

Concern over adequate spillway capacity in 1979 prompted the Association to modify the spillway. The far left portion of the spillway, was widened 5.0 ft and deepened 1.4 ft as shown in Figures 3A and 3B and Photo 5. Although a land survey was completed for the reservoir area, the modification was done without formal engineering consultation.

No other records of the dam design or construction have been identified.

- h. Normal operating procedures. No operating records or procedures were found. Flood flows pass over the uncontrolled spillway at the northwest (left) abutment.

1.3 Pertinent Data

a. Drainage area. Approximately 0.23 mi².

b. Discharge at dam site.

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	Not applicable (N/A)
Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	250 ft ³ /sec
Total spillway capacity at maximum pool elevation	250 ft ³ /sec

c. Elevations (ft above MSL).

Top Dam	884.5 to 886.1
Maximum pool-design surcharge	N/A
Full flood control pool	N/A
Recreation pool	883.1
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Maximum tailwater	N/A
Toe of dam at maximum section	858.8

d. Reservoir.

Length of maximum pool (estimated)	1100 ft
Length of recreation pool (estimated)	1000 ft
Length of flood control pool	N/A

e. Storage (acre-ft).

Recreation pool	92
Flood control pool	N/A
Design surcharge	N/A
Top of dam	107

f. Reservoir surface (acres).

Top of dam	11
Maximum pool	11
Flood-control pool	N/A
Recreation pool	10
Spillway crest	10

g. Dam.

Type	Uncontrolled earth fill
Length	551 ft
Height	27 ft
Top width	6.5 ft
Side slopes	D/S 2.5H to 1V U/S unknown
Zoning	Unknown
Impervious core	Unknown (probably homogeneous section)
Cutoff	Unknown (probably to bedrock at shallow depth)
Grout curtain	Unknown

h. Diversion and regulating tunnel. N/Ai. Spillway.

Type	Trapezoidal, concrete lined
Length of weir	48.3 ft
Crest elevation, main spillway	883.1 ft, MSL

Crest elevation, low-level spillway	881.7 ft, MSL
Gates	None
Upstream Channel	None
Downstream Channel	In situ residual soil sides, bedrock floor

j. Regulating outlets. None

SECTION 2 ENGINEERING DATA

2.1 Design

No design drawings or reports have been found for this dam.

2.2 Construction

No construction reports have been found on this dam, but Mr John Harsh, President of the Spring Lake Subdivision Board of Trustees, indicates the dam was constructed in 1952, and was assumed to be founded on bedrock at shallow (4-10 ft) depth.

2.3 Operation

There are no control structures on this dam. There are no records of the flows over the dam; however, Mr Harsh indicated that an 11 inch rainstorm around 1957, left residents' boats on the crest of the dam suggesting the dam had been at least partially overtopped.

2.4 Evaluation

- a. Availability. Engineering data was obtained through personal interviews with Mr Harsh.
- b. Adequacy. The available information is insufficient to evaluate the design of the Spring Lake Dam. Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be rectified. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be performed by an engineer experienced in the design and construction of dams.

- c. **Validity.** The engineering information was obtained from the president of the owners' association, but the information was not confirmed by an outside source and is incomplete.

2.5 **Project Geology**

The Spring Lake Dam is located on the northern flank of the Ozark structural dome. The regional dip of the bedrock is to the north. The bedrock in the vicinity of the dam is mapped on the geologic map of Missouri (Fig. 4) as Ordovician age cherty and sandy dolomite formations, the Roubidoux Formation and the underlying Gasconade Formation.

The Roubidoux Formation consists of sandstone, dolomitic sandstone and cherty dolomite. The dolomite is finely crystalline, light gray and brown and thinly to thickly bedded. The formation is on the order of 100 ft thick in the northeastern part of the Ozarks.

The Gasconade is predominantly a cherty dolomite, light brownish-gray in color. The upper part of the formation, in the vicinity of the dam is generally finely crystalline dolomite with relatively minor amounts of chert. Caves and springs are common in this formation and the dam owner indicated the lake was spring fed. However, no evidence of solution activity was noted during the field inspection.

The soil exposed at the damsite is a red brown, stoney plastic clay (CL-CH), characteristically developed as a residual soil of insoluble residue on the weathered carbonate bedrock. The soil is mapped on the Missouri general soils map as Union-Goss-Gasconade-Peridge Association, which is described as deep to shallow, loamy to clayey upland soils with moderate to slow permeability.

The Richwoods Fault Zone is mapped on the Structural Features Map of Missouri (1971) less than one half mile north of the dam site. The fault zone is approximately 7 mi in length, trending north-northwest. The fault is mapped north side up.

This fault, like others in the Ozark area appears confined to the Paleozoic bedrock and is likely Paleozoic in age. The area is not considered to be seismically active.

SECTION 3 VISUAL INSPECTION

3.1 Findings

- a. General. A field inspection was made of the Spring Lake Dam on 16 July 1980. The dam is currently generally in good condition.
- b. Dam. The dam is constructed of a gravelly clay, with about 15 percent angular gravel and less than 5 percent sand, with medium to high dry strength. It is a light brown to red, residual clay (CL-CH).

The side slopes of the embankment range from 1.5H:1V to 2.5H:1V, and are generally in a well maintained condition. The slopes are grass covered with some berry bushes and small saplings (Photo 6). Approximately a 10 ft by 20 ft area at the toe of the dam is covered with swamp vegetation. There was one shallow (about 12 to 18 in. deep) slump observed, about 45 ft wide, in the center third of the downstream face about midway up from the toe. The slump is vegetated with grass and apparently not recently active. A few other small irregularities were also observed on the downstream slope.

The upstream face of the dam is well maintained and is protected by sub-angular, cobble sized riprap, as shown in Photo 7.

The crest of the dam appears relatively level. Settlement of the dam crest was not apparent, although minor elevation fluctuations (+three in.) were noted. Lateral spreading or displacement of the dam's profile was not noticed. The dam crest is shown in Photos 1 and 7.

There were no erosion channels, gulying or rill wash evident on the dam, but minor gulying was noted on the hillside downstream of the southeast abutment. This gulying is shown in Photo 1, and does not affect the dam embankment. The erosion potential for the dam embankment is relatively low, due to the clayey material and good vegetative cover.

Seepage was noted in the area of swamp vegetation, but due to the extremely hot, dry conditions preceding the visit, the volume of seepage was very low (less than one gallon per minute) and was not transporting any soil particles.

c. Appurtenant structures.

1. Spillway. The spillway consists of a 43 ft wide, concrete lined, trapezoidal spill area and a concrete broad-crested weir. There is an additional five ft wide rectangular, low-level flow channel as shown in Photos 4 and 5 and Figures 3A and 3B. The concrete was in good condition with no spalling or cracking evident. At the interface of the concrete spillway and the downstream channel, however, substantial erosion of the soil has taken place.

According to the owners' representative the reservoir is spring-fed. Currently, the reservoir is at a lower than normal elevation. During non-dry seasons, the five ft low level trough typically carries water.

The approach to the spillway was found to be heavily sedimented and grassy. The elevation of the bottom of the approach channel was found to be higher than the low-level spillway in some places.

Two rows of lightweight fencing have been placed around the approach to the spillway to control debris flow into the spillway and to control the loss of fish from the reservoir, and can be seen in Photo 4. This fencing probably is the cause of sedimentation in this area.

2. Outlet works. Two 2-in. inside diameter siphon tubes were installed to lower the reservoir level. The siphons discharge at the toe of the slope at approximately the maximum dam section as noted in Figure A-1, Appendix A. The siphons do not provide significant enough flow to erode more than a shallow gully. This gully joins the discharge channel and the downstream drainage system about 100 ft northeast of the siphon discharge point.

d. Reservoir area. The slopes of the reservoir area are approximately 5H:1V, or flatter and are typically grassy. The stone or gravel and small cobbles at the beach face, provide some minor erosion control. Bank erosion is in the form of

rill wash and wave action around the perimeter of the reservoir. Rill wash and other forms of erosion have caused a sedimentation rate of approximately three in. per year according to Mr Harsh.

The reservoir banks and surrounding hillsides are well settled with homes and the slopes appear to be stable with no slides noted during the field inspection. The foundation soil of the buildings and reservoir banks is a stony, plastic, residual clay (CL-CH) developed on Potosi Dolomite.

- e. Downstream channel. The downstream channel is unlined and does not appear to be maintained. The in situ soil is a stony residual clay (CL-CH) that has been eroded to the Potosi Dolomite bedrock floor, immediately downstream of the low-level spillway section. The gulying of the downstream channel varies from approxiamtely three feet deep as shown in Photo 8, to eight feet deep about 75 ft downstream of the spillway, as shown in Photo 9. This indicates the residual soil is moderately susceptible to erosion.

Water was present in the downstream channel approximately 100 ft downstream of the spillway, and was seeping from the bedrock/soil interface at less than one gallon per minute.

Trees were found to line the channel, and were of sufficient size to possibly interfere with flood flow. These trees can be seen in Photos 1 and 9. In their present condition they pose little interference, but if continued erosion undermines and fells the trees, they could obstruct high flows and possibly divert the discharge channel toward the toe of the dam, which could cause undesirable erosion of the dam toe.

3.2 Evaluation

The visual inspection identified only minor items of concern, but if they are left unchecked they may in time contribute to deterioration of the dam. The most important of these items is the condition of the downstream channel, being unprotected against further erosion. Other items include the obstruction of flow to the spillway entrance, one inactive small slope failure scarp, local seepage at the toe of the embankment and the presence of small brush and sapling growth which

should be removed. The seepage should be monitored to detect any changes in amount or turbidity of flow.

SECTION 4 OPERATIONAL PROCEDURES

4.1 Procedures

No facilities requiring operation were identified at this dam site. Water level in the reservoir is controlled by the ungated five ft wide low-level channel, the broad-crested weir, and occasionally the two siphon tubes.

4.2 Maintenance of the Dam

No records of maintenance were identified for this dam, but continuing maintenance of the riprap on the upstream face is evident from the inspection and through interviews with Mr Harsh.

4.3 Maintenance of Operating Facilities

No facilities requiring operation exist at this dam.

4.4 Description of any Warning System in Effect

A warning system was not identified in the inspection.

4.5 Evaluation

There is no formal maintenance program for this dam, but general concern over the appearance and safety of the dam and reservoir is evident by the periodic maintenance of the upstream riprap, and the modifications to the banks, spillway and dam crest. Maintenance is needed in the downstream channel to protect against further erosion, and in the approach to the spillway to remove the accumulated sediment and to prevent spillway blockage by debris clogging at the fences. The development of a periodic maintenance program and an evaluation of a practical and effective warning system are recommended for this facility.

SECTION 5 HYDROLOGY/HYDRAULICS

5.1 Evaluation of Features

- a. Design data. No hydrologic or hydraulic design data were available for evaluation of this dam or reservoir; however, dimensions of the dam were field surveyed. Other relevant data were estimated from topographic mapping. The maps used in the analysis were the US Geological Survey Richwood NE and Richwood SE 7.5 minute quadrangle maps.
- b. Experience data. No recorded rainfall, runoff, discharge or pool stage historical data were found for this reservoir.
- c. Visual observations.
 1. Watershed. The watershed is natural woods, forested with mixed hardwoods and softwoods. The area of the reservoir is approximately 7 percent of the total drainage area of 0.23 sq. mi.
 2. Reservoir. The reservoir and dam are best described by the maps and photographs enclosed herewith. The primary use of this impoundment is for recreation.
 3. Spillway. The concrete, ungated spillway is located at the northwest end of the dam abutting the natural hillside. It is approximately trapezoidal in shape and has a small rectangular side channel for low discharge. The steep elevation drop in the discharge channel below the spillway indicates that the spillway acts as the control section for maximum flow.
 4. Seepage. The magnitude of seepage through this dam is very small and not hydrologically significant to the overtopping potential.

- d. Overtopping potential. One of the primary considerations in the evaluation of Spring Lake Dam is the assessment of the potential for overtopping and consequent failure by erosion of the embankment. Since the spillway of this dam is concrete, deep erosion at the control section of the spillway due to high velocity discharge is not expected to be a major consideration. The lowest portion of the dam which is adjacent to the southeast end of the spillway was considered to be the top of dam for the purpose of determining the overtopping potential.

Hydrologic analysis of this dam for the 1 and 10 percent probability-of-occurrence and Probable Maximum Floods (PMF) were all based on initial water surface elevations equal to the spillway crest elevation. This is supported by the field survey which established that the high water mark is slightly above that of the spillway crest. The results of the analysis indicate that a flood of greater than 19 percent of the PMF will effectively overtop the dam. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The analysis also indicates that the spillway will pass the 10 percent probability-of-occurrence flood but will not pass the 1 percent probability-of-occurrence flood (100-yr flood) without overtopping the dam at the spillway. The total spillway capacity at maximum pool elevation (top of dam) is 250 ft³/sec.

The following overtopping data for the PMF ratio storms were computed for the dam:

Precipitation Event	Max. Reservoir W.S. Elev.	Max. Depth Over Dam, ft	Max. Outflow, ft ³ /sec	Duration of Overtopping, hrs
20% PMF	884.54	0.04	264	0.3
50% PMF	885.6	1.1	930	3.1
100% PMF	886.2	1.7	2010	5.83

It should be noted that at the PMF the depth of overtopping will reach nearly two feet and the dam will be overtopped for nearly six hours. During this time, significant erosion would very likely take place at the left abutment adjacent to the spillway. With the available data the total effect on the dam's safety cannot be properly evaluated. It is felt, however, overtopping for nearly six hours could develop into an effective dam breach.

SECTION 6 STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

- a. Visual observations. The visual inspection of the Spring Lake Dam revealed that it is in generally good condition. There was no evidence of lateral spreading or horizontal displacement of the dam crest. The survey indicated that the elevation of the dam crest varied ±three in., and may be a result of settlement or lax construction control, neither of which can be supported without prior monitoring of the dam. There was no evidence of sinkholes or cracking in the dam, but a relatively small earth slump was noted on the downstream face. This slump was vegetated by grasses and did not appear to have occurred recently. A few small (two in. dia) animal burrows were noted but did not appear to affect the dam's stability.

Minor seepage was found in the area of the toe (Figure A-1, Appendix A), but evidence of piping was not found in this area. Seepage seen in the downstream spillway channel is, in our opinion, a natural spring from the hillside and not from reservoir seepage.

The spillway appears to be in good structural condition but should be checked periodically for deterioration.

The downstream channel is in relatively poor physical condition due to erosion. The bottom of the channel has been eroded to bedrock in some places and the soils on both banks are loose and being eroded. Continued flow in the channel will erode and widen the already steepened banks; however, the channel erosion should not endanger the toe of the dam.

Uncorrected headward erosion at the toe of the spillway could undermine the concrete lining and endanger the spillway.

- b. Design and construction data. No design or construction records were available for this dam. All information was obtained through interviews with Mr John Harsh. He provided lake depth, overtopping, and modification information, and some information on the original dam construction. Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be rectified.
- c. Operating records. No operating records or water level records are maintained for this facility.
- d. Post construction changes. The dam crest was raised 18 inches in 1954 and has apparently not decreased the dam's stability. The steepening of the reservoir banks and the 1976 spillway modification has not apparently adversely affected the stability of the dam. The addition of the five foot wide spillway trough in 1979 may have increased erosion at its discharge as shown in Photo 8.
- e. Seismic stability. The dam is in Seismic Zone 2 to which the guidelines assign a moderate damage potential. During a seismic event, liquefaction of the reportedly gravelly clay dam material is unlikely. However, without knowledge of soil properties the seismic stability of the dam cannot be evaluated.

SECTION 7 ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

- a. **Safety.** Based on the visual inspection, the dam appears to be in fair condition. Inadequate spillway capacity is the primary reason for this judgment. The hydrologic analysis of the spillway, dam, and the reservoir storage indicates that the spillway will pass only 19 percent of the PMF without overtopping the dam. Seepage and stability analyses comparable to the requirements of the guidelines and which would better allow evaluation of the safety of the embankment are not on record.
- b. **Adequacy of information.** The visual inspection provided a reasonable base of information for the conclusions and recommendations presented in this Phase I report. The lack of design documents such as static and seismic stability analyses and seepage analysis precludes an evaluation of the static and seismic stability of the dam. This is a deficiency which should be corrected.
- c. **Urgency.** The deficiencies described in this report could affect the safety of the dam. The studies described in Section 7.2b.1 concerning the spillway design flood should be performed on a high priority basis.
- d. **Necessity for Phase II.** In accordance with the Recommended Guidelines for Safety Inspection of Dams, the subject investigation was a minimum study. This study revealed that additional in-depth investigations are needed to complete the assessment of the safety of the dam. Those investigations which should be performed without undue delay are described in Section 7.2.b. It is our understanding from discussions with the SLD that any additional investigations are the responsibility of the owner.

7.2 Remedial Measures

- a. Alternatives. There are several general options which may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:
 - a. Remove the dam or breach it to prevent storage of water.
 - b. Increase the height of dam and/or spillway size to pass the probable maximum flood without overtopping the dam.
 - c. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.
 - d. Enhance the stability of the dam to permit overtopping by the probable maximum flood without failure.
 - e. Provide a highly reliable flood warning system (generally does not prevent damage but avoids loss of life).
- b. Recommendations. Based on our inspection of the Spring Lake Dam, it is recommended that the following topic be evaluated on a high priority basis (without undue delay):
 1. Prepare a hydrologic design to increase the capacity of the spillway or increase the dam height to be able to pass 100% percent of the PMF without overtopping the dam. This recommendation is based on the fact that, for the present conditions, overtopping of the dam for nearly six hours by the 100 percent PMF could develop into a virtual dam breach which would release most of the reservoir contents in a fairly short time. Further detailed hydrologic studies, as well as inundation studies which are all beyond the scope of this report, may well show that designing and constructing the spillway to accommodate a spillway design flood of less than 100 percent of the PMF would reduce the depth and duration of overtopping by the 100 percent PMF to acceptable amounts.

Further recommendations which should be addressed as soon as practical are the following:

2. Reconstruction of the downstream spillway channel to a point downstream where the dam will not be jeopardized by further erosion.
3. Removal of possible flow obstructions from the downstream channel such as large trees.
4. Clearing of the spillway approach of sediment and obstructions to flow and prevent further accumulation of debris and sediments.
5. Performance of seepage and stability analyses in accordance with the requirements of the guidelines.
6. Investigation of the feasibility of a warning system to notify downstream residents should potentially hazardous conditions develop.

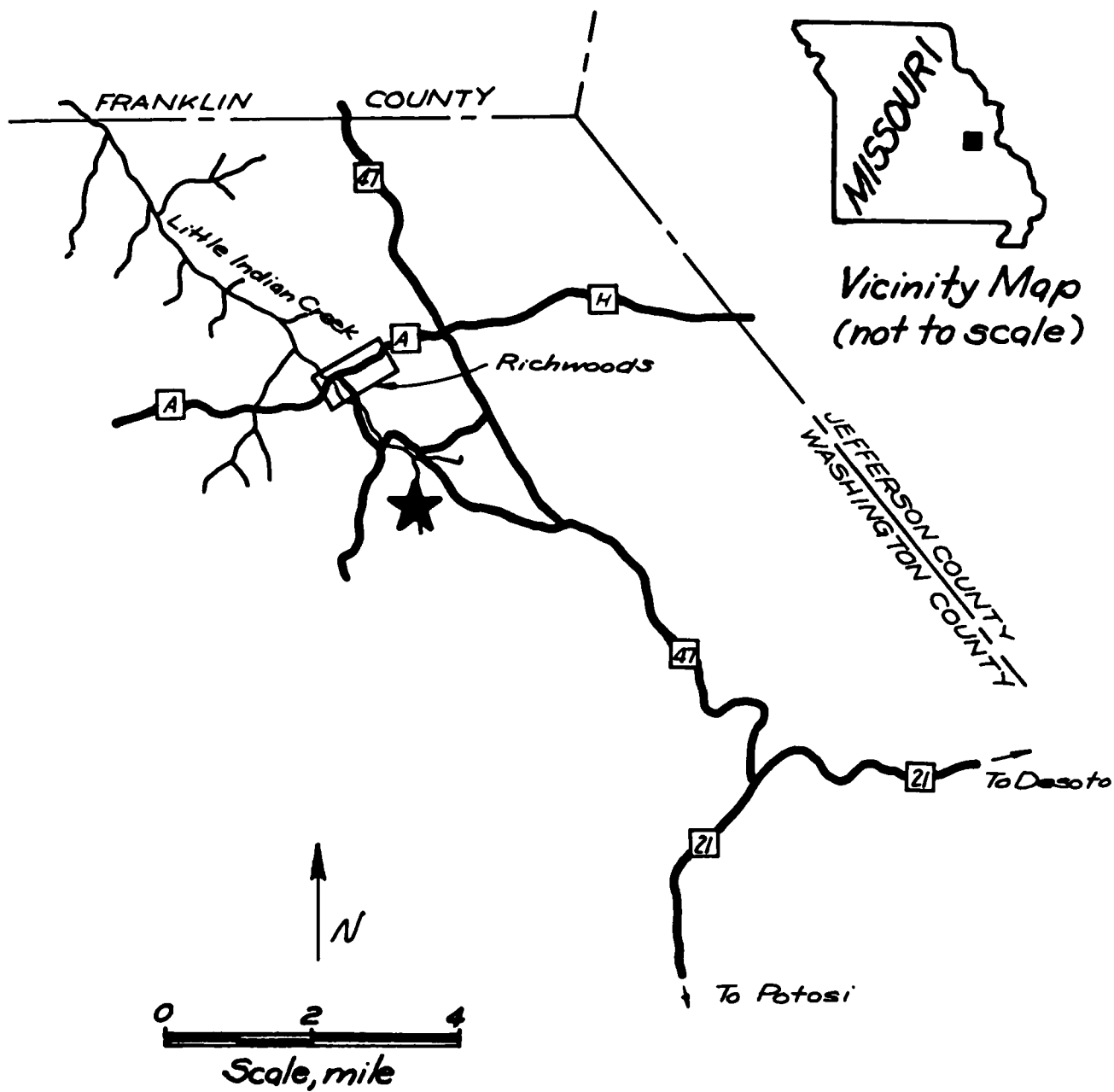
All remedial measures should be evaluated and performed under the guidance of an engineer experienced in the design and construction of earthen dams.

- c. **O & M procedures.** As there are no operable facilities per se, it is recommended that a program of periodic inspections be developed and implemented to identify, as a minimum, evidence of instability such as slumping on the embankment, and to monitor seepage from the toe of the dam. Changes in conditions such as increased seepage volume or turbidity in the seepage water should be evaluated. The result of the inspection program should be to identify maintenance that is necessary. Maintenance should include the maintaining of the downstream channel and the dam slopes free of trees and bushes.

All inspections and maintenance should be evaluated and/or performed by an engineer experienced in the design and construction of earthen dams.

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- Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, Scale 1:500,000.
- St Louis District, US Army Corps of Engineers, 1979, "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams".
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- US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.



Legend

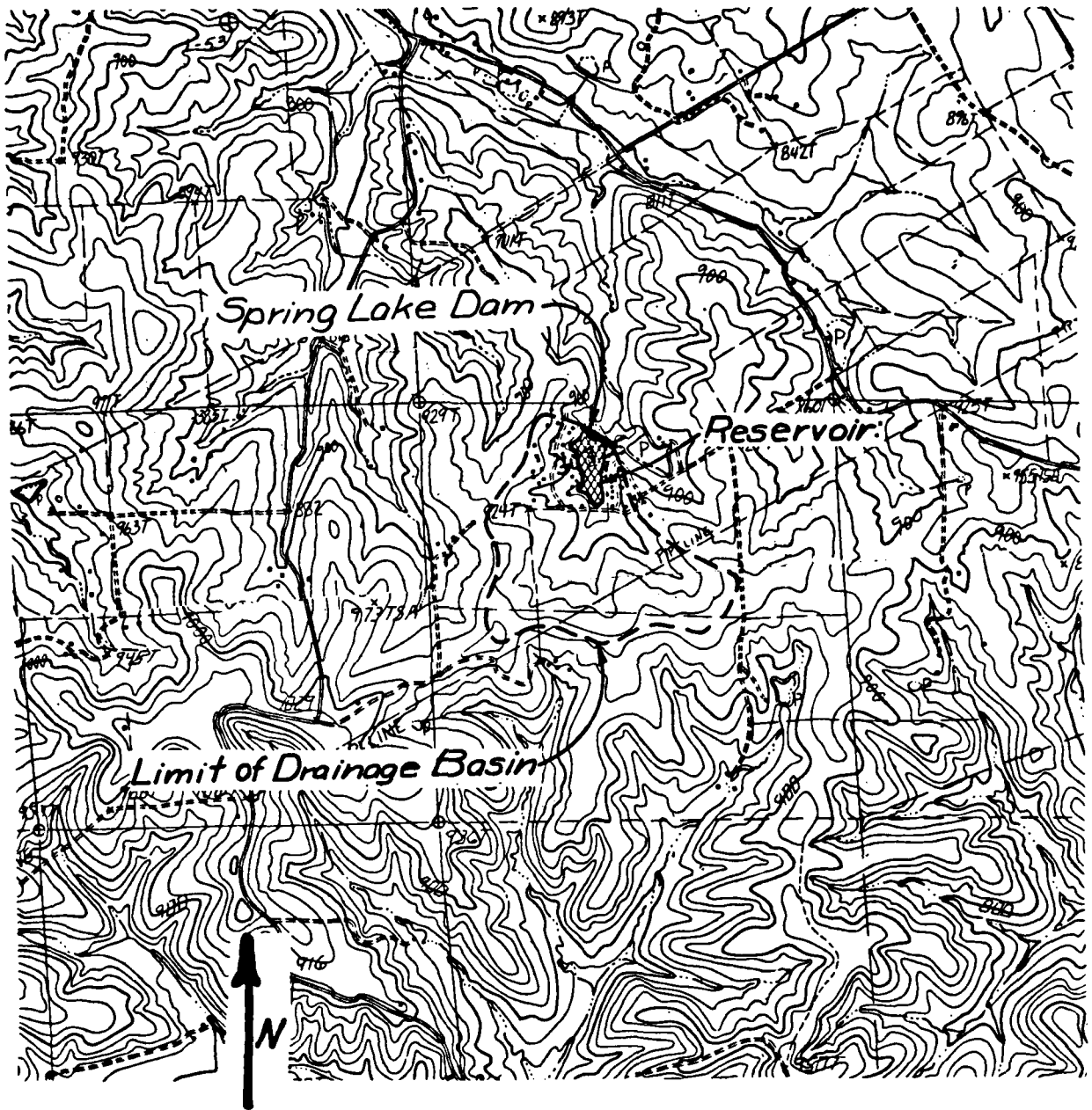
- County Line
- State highway and Route No.
- ~ River or Creek
- City or Town
- ★ Project location

SITE LOCATION MAP

SPRING LAKE DAM

MO 30725

Fig. 1



0 2000 4000
Scale, ft

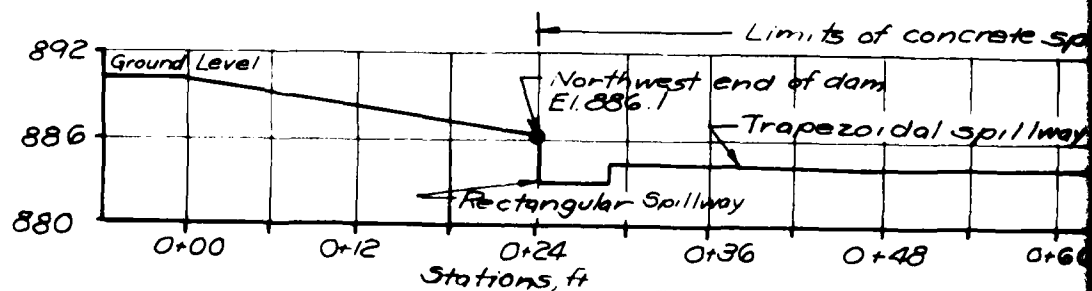
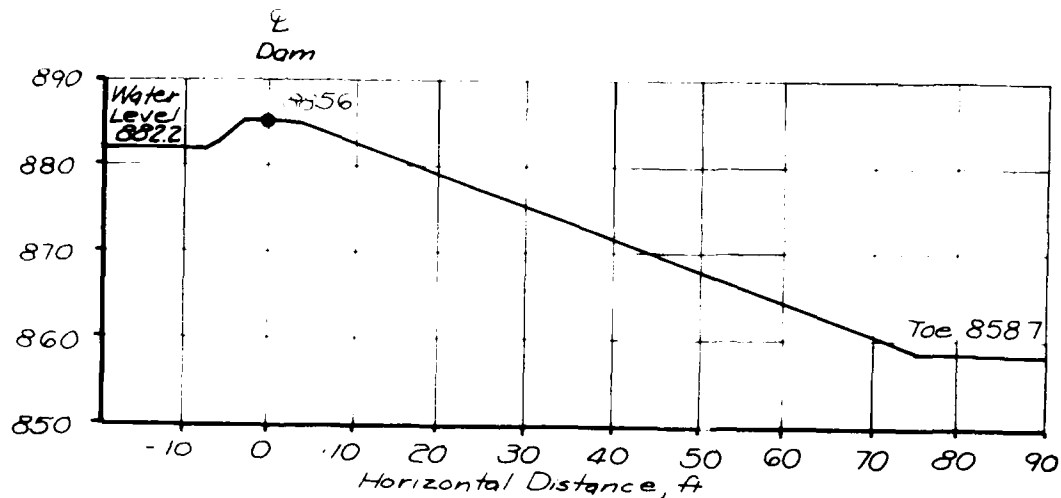
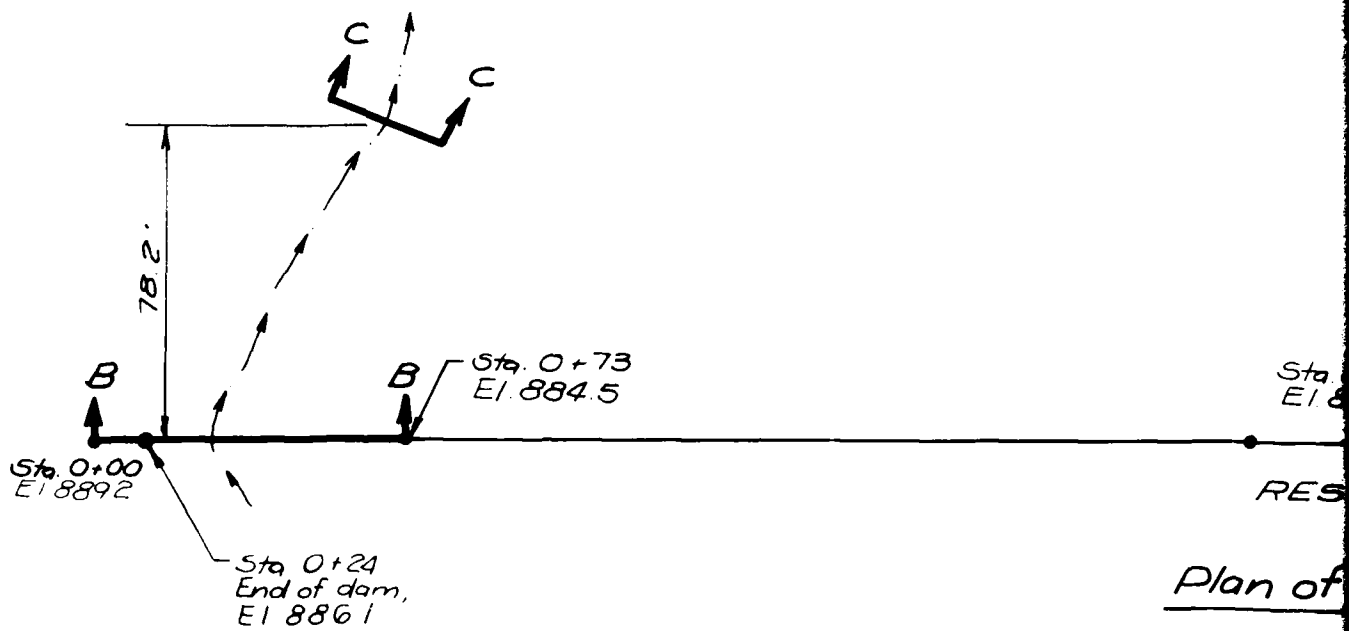
1. Topography from U.S.G.S.
Richwoods NE and
Richwoods SE 7 1/2 minute
quadrangle map.

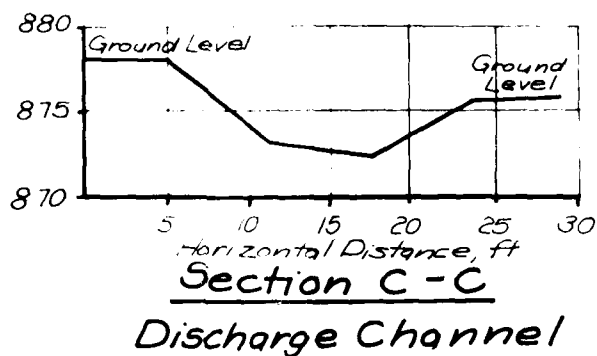
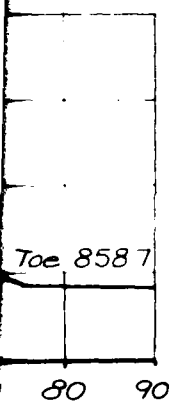
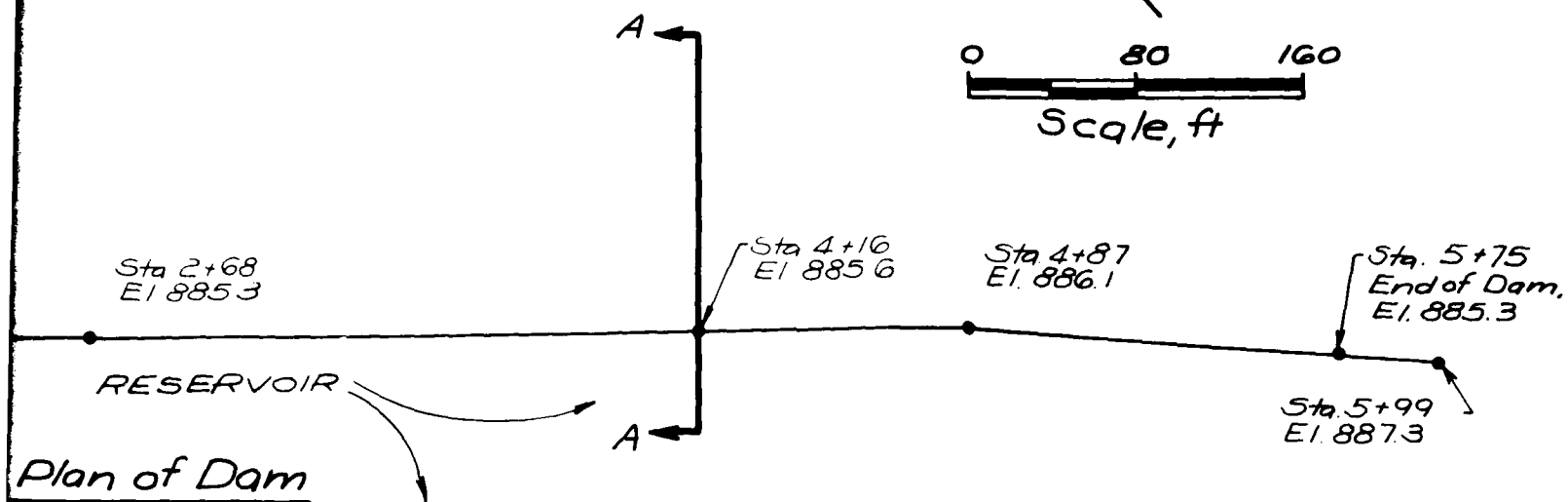
DRAINAGE BASIN AND SITE TOPOGRAPHY

SPRING LAKE DAM

MO 30725

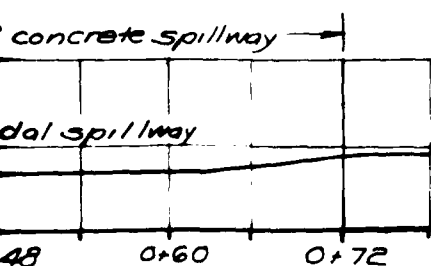
Fig. 2



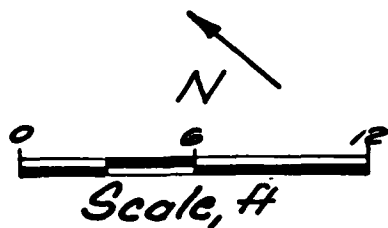
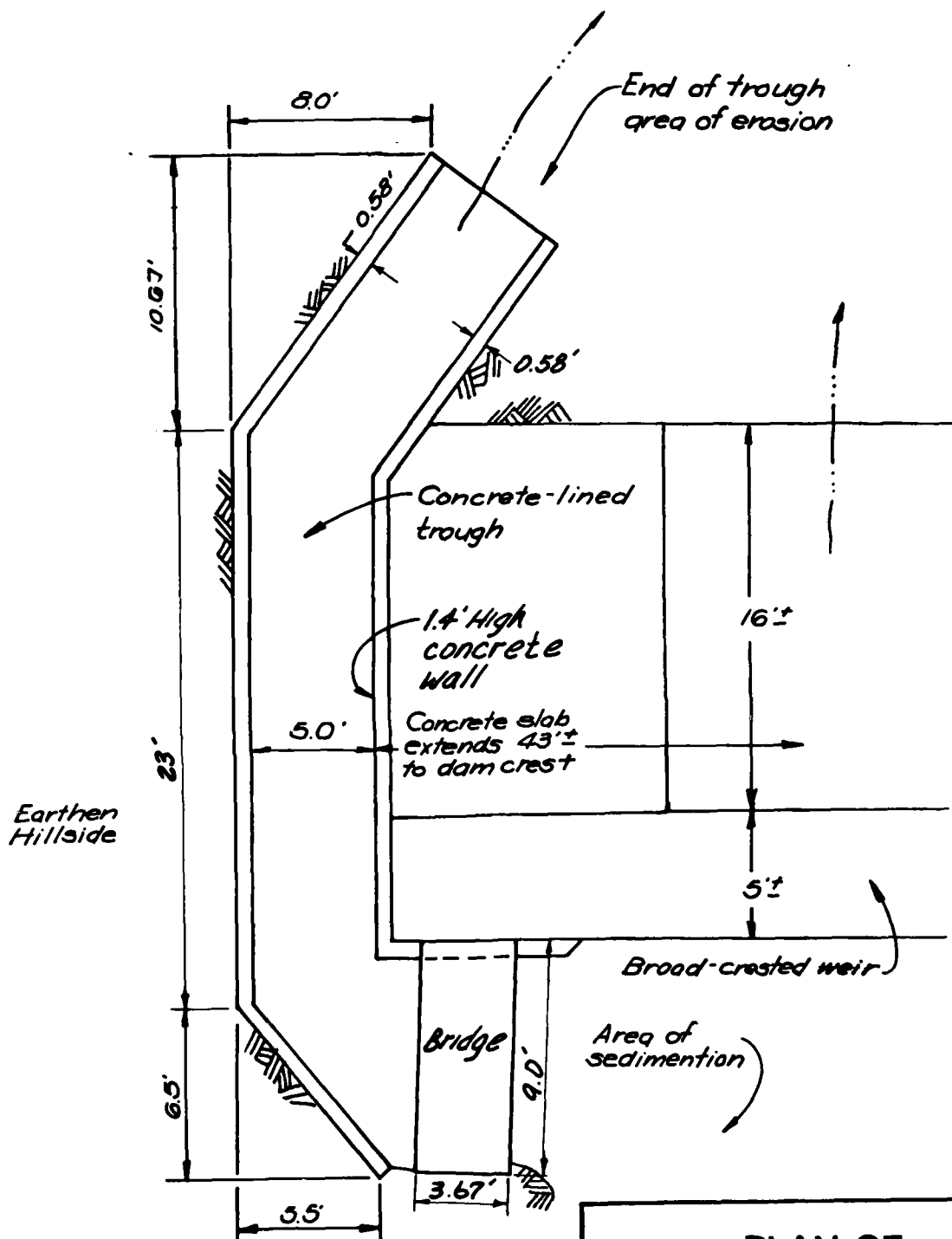


Legend

Discharge Channel



PLAN AND SECTIONS OF DAM AND SPILLWAY	
SPRING LAKE DAM	
MO. 30725	Fig. 3-A



PLAN OF SPILLWAY TROUGH

SPRING LAKE DAM

MO 30725

Fig. 3-B

DAM LOCATION



Legend

Or

Roubidoux Formation

Gasconade Dolomite
Gunter Sandstone Member

Cep

Eminence Dolomite

Potosi Dolomite

Derby-Doerun Dolomite

Davis Formation

Ceb

Bonneterre Formation
Whetstone Creek Member
Sullivan Siltstone Member

Reagan Sandstone
(subsurface, western Missouri)

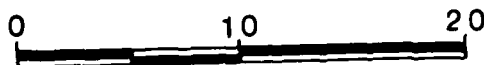
Lamotte Sandstone



Diabase (dikes and sills)

St. Francois Mountains Intrusive Suite

St. Francois Mountains Volcanic Supergroup



Scale. mile

REGIONAL GEOLOGIC MAP

SPRING LAKE DAM

MO 30725

Fig. 4

APPENDIX A
Photographs

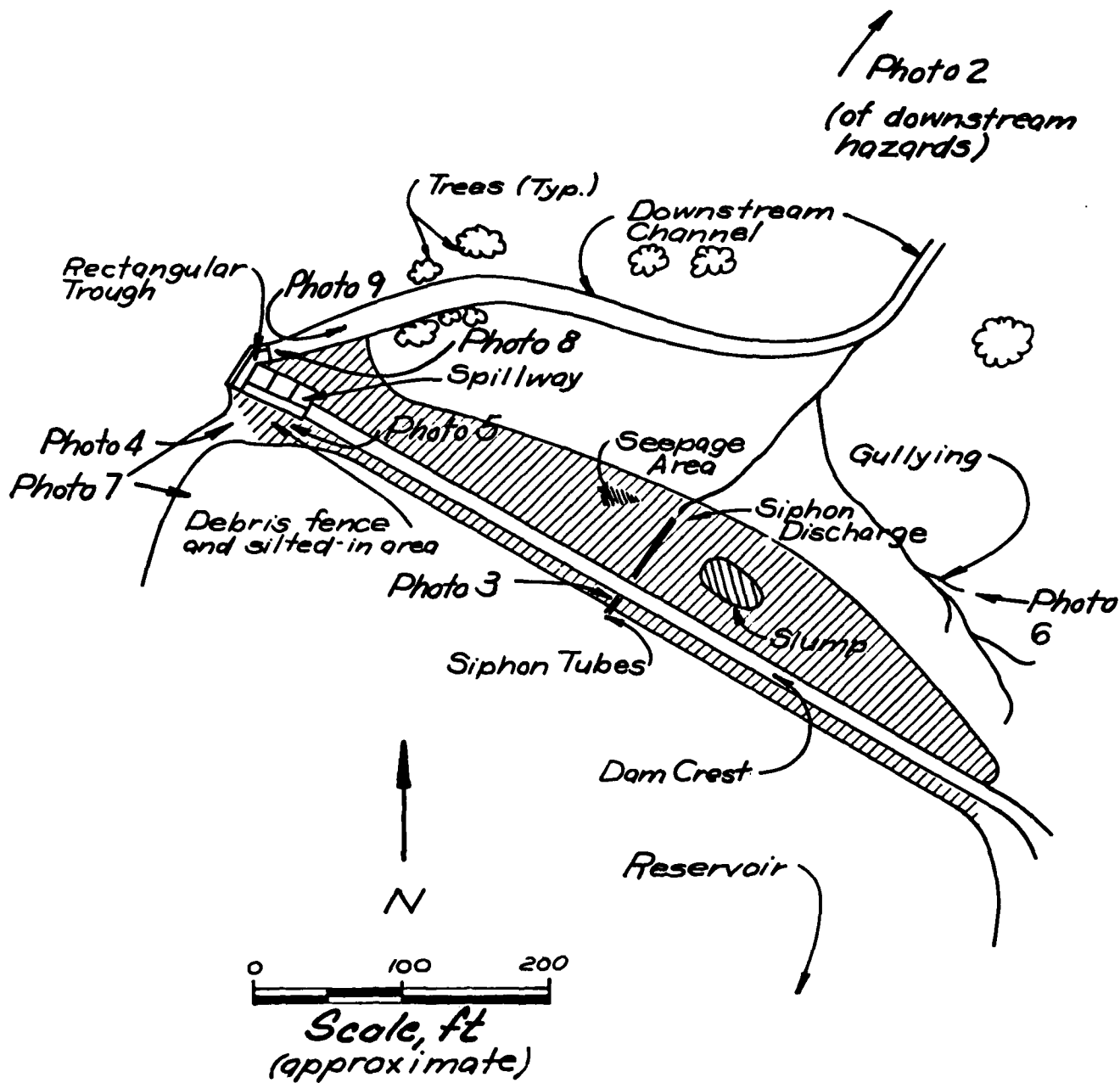
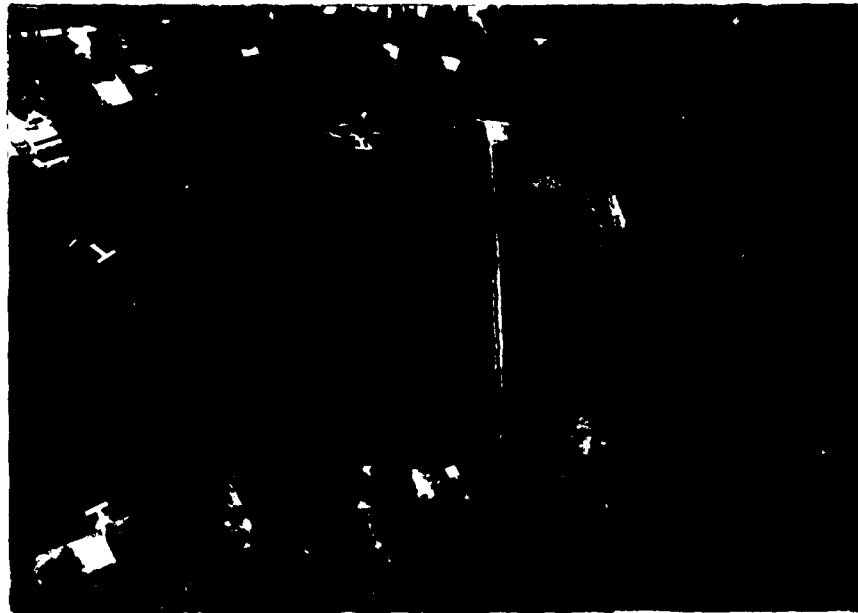


PHOTO LOCATION SKETCH

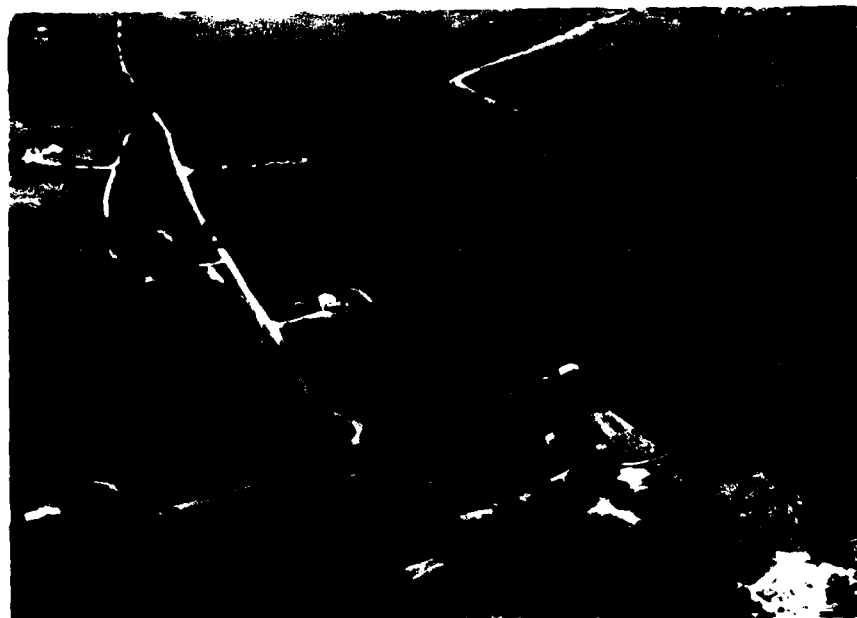
SPRING LAKE DAM

MO 30725

Fig. A-1



1. Spring Lake Dam alignment, spillway, downstream channel and hillslope erosion; looking northwest.



2. Downstream hazards below Spring Lake Dam.



3. Two inch siphon tubes.



4. Broad-crested weir with 4 inch pipes, trapezoidal spill area, debris and fish fence; looking northeast with dam to the right.



5. Rectangular flow channel starts beneath the footbridge, broad-crested weir to the right; looking northwest.



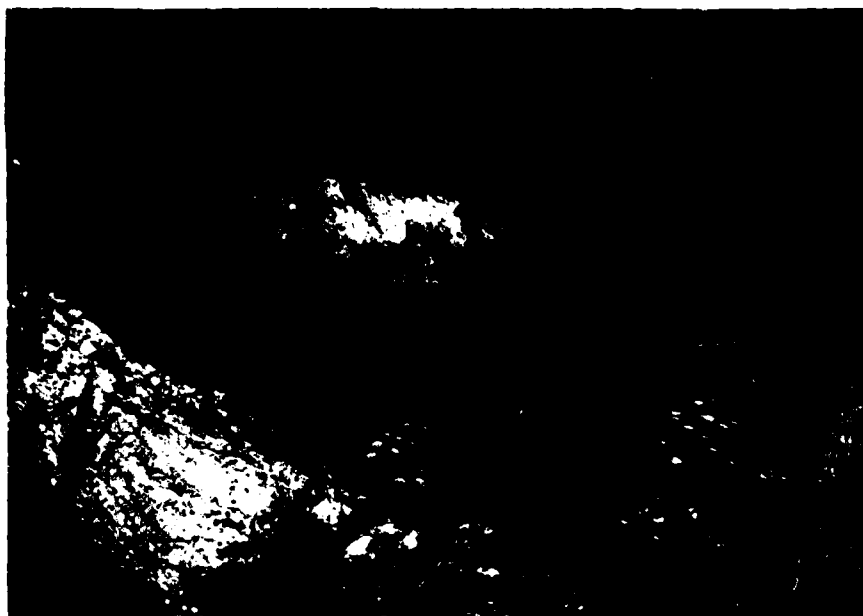
6. Downstream face of dam indicating size and type of vegetation. Swampy area in center of photo; looking west.



7. Upstream face of dam showing water level, riprap and crest condition; looking southeast.



8. Gullying to bedrock downstream of the discharge end of the 5.0 ft wide low-level flow channel.



9. Downstream channel of Spring Lake Dam showing erosion and vegetation; looking northeast.

APPENDIX B
Hydraulic/Hydrologic Data and Analyses

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

B.1 Procedures

- a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.
- b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956).
- c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (National Engineering Handbook, Section 4, Hydrology, 1971) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi², and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{1^{0.8} (s+1)^{0.7}}{1900 Y^{0.5}} \quad (\text{Equation 15-4})$$

where: L = lag in hours
 P = hydraulic length of the watershed in feet
 $s = \frac{1000}{CN} - 10$ where CN = hydrologic soil curve number
 Y = average watershed land slope in percent

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \quad (\text{Equation 15-3})$$

where: T_c = time of concentration in hours

L = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was estimated utilizing the following relationship:

$$\Delta D = 0.133T_C \quad (\text{Equation 16-12})$$

where: ΔD = duration of unit excess rainfall
 T_C = time of concentration in hours.

The final interval was selected to provide at least three discharge ordinates prior to the peak discharge ordinate of the unit hydrograph. For this dam, a time interval of 5 minutes was used.

- d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS curve number method. The curve numbers were established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) degree of development, (d) vegetative cover and (e) present land usage in the watershed.

Antecedent moisture condition III (AMC III) was used for the PMF estimates and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

- e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows:

- (1) 1 and 10 percent probability events - spillway crest elevation which is also the high water mark
- (2) Probable Maximum Storm - spillway crest elevation

Because the siphon tubes are of small diameter, it was assumed they were either blocked or inoperable and did not pass any amount of the flood.

- f. Spillway Rating Curve. The basic weir equation was utilized to compute the spillway rating curve. The weir equation is as follows:

$$Q = CLH^{3/2}$$

where Q = discharge in cubic feet per second
 L = effective length of spillway in feet
 C = coefficient of discharge (2.5 to 3.1)
 H = total head over spillway in feet

B.2 Pertinent Data

- a. Drainage area. 0.23 mi²
- b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 24 hours duration was divided into 5 minute intervals in order to develop the inflow hydrograph.
- c. Lag time. 0.34 hrs
- d. Hydrologic soil group. D
- e. SCS curve numbers.
 1. For PMF- AMC III - Curve Number 92
 2. For 1 and 10 percent probability-of-occurrence events AMC II - Curve Number 81
- f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Richwoods NE and SE 7.5 minute quadrangle maps. The data were entered on the \$A and \$E cards so that the HEC-1 program could compute storage volumes.
- g. Outflow over dam crest. As the profile of the dam crest is irregular, flow over the crest was computed according to the "Flow Over Non-Level Dam Crest" supplement to the HEC-1 User's Manual. The crest length-elevation data and hydraulic constants were entered on the \$D, \$L, and \$V cards.
- h. Outflow capacity. The spillway rating curve was developed from the cross-section data of the spillway and the downstream channel, using the HEC-2 back water program. The results of the above were entered on the Y-4 and Y-5 cards of the HEC-1 program.
- i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevation was 883.1 ft, the spillway crest elevation. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was 883.1 ft, the elevation of the high water line in the reservoir area which is also the spillway crest elevation.

B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-1 output are available in the project files.

 FLOOD PREDICTION PACKAGE (FPP) (1)
 LPP SAFETY VERSION JULY 1974
 LAST MODIFICATION 11 APR 75

1	A1	DAM NO.	30725	-	SPRING LAKE, WASHINGTON COUNTY, MISSOURI.				
2	A2	WELSHAND-CLAY CONSULTANTS, FOUNTAIN JLP 154000.							
3	A3	PERMANENT FLOOD FLOODS (PFF) ANALYSIS.							
4	H	200	0	5	-0	-0	-0	-0	-0
5	H1	5							
6	J	1	2	1					
7	J1	50	1.00						
8	K	0	0-1M						
9	K1	SPRING LAKE INFLOW COMPUTATION. PFF RATIO FLOODS.							
10	P	1	2	0.23	120.	120.			
11	P1	0	26.	102.	120.	120.			
12	I								
13	K2		0.34						
14	K	-1	-0.05						
15	K1	SPRING LAKE PFF FLOOD ROUTING.							
16	V								
17	V1	1							
18	V4	002.	052.0	053.1	041.0	044.	044.3	044.5	045.5
19	V5	0.	1.2	1.5	10.2	13.	13.	13.	13.
20	V6	0.	4.	7.7	10.3	11.0	14.2	14.2	14.2
21	V7	0.	0.0.	0.0.	053.1	044.5	044.5	044.5	044.5
22	V8	003.3							
23	V9	004.5	2.0	1.5					
24	V10	004.5	130.	310.	475.	515.			
25	V11	004.5	005.	005.5	056.	056.			
26	V12	004.5							
27	K								

Input Data
 Various PMF Events
 Spring Lake Dam
 MO. ID. No. 30725
 B4

DATE: 14 SEP 1964
TIME: 14.51.34

JUG SPECIFICATION	
NR	NR
0	0
5	5
10	10
15	15
20	20
25	25
30	30
35	35
40	40
45	45
50	50
55	55
60	60
65	65
70	70
75	75
80	80
85	85
90	90
95	95
100	100

MULTI-PLAN ANALYSIS TO BE PERFORMED
NPLAN= 1 NRTU= 2 LRTU= 1

43105-04-1

SUB-AKE A UNIT COMPLETION

SPRING LAKE INFLOW COMPUTATION. HOT WATER FIELDS.

ISTAQ	ICUMP	IFCCN	ITAPP	JPL1	JPR1	INAME	ISTAGE	IAUGC
Q-IN	0	-0	-0	-0	-0	1	-0	-0

01574444 01574444

SPFE	PMS	N6	PRECIP DATA	
0.	26.00	102.00	W12	W24
			129.00	130.00

MISS DATA

	LOGPT	STARR	DLIAR	KIHL	TRAIN	STARS	KIOLK	STRTL	CNSTL	ALSMX	TIME
	-0	-0	-0	1.00	-0	-0	1.00	-1.00	-92.00	-0	.10

(U) 177+17 (0) 1- = 55 INI + M (0) 26- = ON 3AKN7

UNII HYDROLYZAPH, LALA
IC = -0. IAC = .34

REFUGEE DATA

[illegible]

Input Data
Various PMF Events
Spring Lake Dam
MO. ID. No. 30725
B5

UNIT HYDROGRAPH 22 END UP PERIOD UNIDATES, IC= -0. HOURS, LAG= .34 VOL= 1.00
 14. 107. 214. 243. 244. 244. 189. 124. 4. 62.
 43. 30. 21. 15. 10. 7. 5. 4. 1. 2.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.

MO. DA	HR. MM	PERIOD	RAIN	EXCS	LOSS	END-UP-PERIOD FLOW COMP D	MO. DA	HR. MM	PERIOD	RAIN	FICS	LOSS	COMP G
1.01	1.00	1	.01	.00	.01	0.	1.01	12.05	145	.22	.22	.00	116.
1.01	1.10	2	.01	.00	.01	0.	1.01	12.10	146	.22	.22	.00	125.
1.01	1.15	3	.01	.00	.01	1.	1.01	12.15	147	.22	.22	.00	145.
1.01	1.20	4	.01	.00	.01	1.	1.01	12.20	149	.22	.22	.00	212.
1.01	1.25	5	.01	.00	.01	1.	1.01	12.25	149	.22	.22	.00	253.
1.01	1.30	6	.01	.00	.01	2.	1.01	12.30	150	.22	.22	.00	245.
1.01	1.35	7	.01	.00	.01	2.	1.01	12.35	151	.22	.22	.00	326.
1.01	1.40	8	.01	.00	.01	2.	1.01	12.40	152	.22	.22	.00	343.
1.01	1.45	9	.01	.00	.01	2.	1.01	12.45	153	.22	.22	.00	357.
1.01	1.50	10	.01	.00	.01	2.	1.01	12.50	154	.22	.22	.00	367.
1.01	1.55	11	.01	.00	.01	2.	1.01	12.55	155	.22	.22	.00	374.
1.01	1.00	12	.01	.00	.01	3.	1.01	13.00	156	.22	.22	.00	378.
1.01	1.05	13	.01	.00	.01	3.	1.01	13.05	157	.27	.26	.00	383.
1.01	1.10	14	.01	.00	.01	3.	1.01	13.10	158	.27	.26	.00	381.
1.01	1.15	15	.01	.00	.01	3.	1.01	13.15	159	.27	.26	.00	402.
1.01	1.20	16	.01	.00	.01	3.	1.01	13.20	160	.27	.26	.00	416.
1.01	1.25	17	.01	.00	.01	3.	1.01	13.25	161	.27	.26	.00	425.
1.01	1.30	18	.01	.00	.01	4.	1.01	13.30	162	.27	.26	.00	441.
1.01	1.35	19	.01	.00	.01	4.	1.01	13.35	163	.27	.26	.00	450.
1.01	1.40	20	.01	.00	.01	5.	1.01	13.40	164	.27	.26	.00	456.
1.01	1.45	21	.01	.00	.01	5.	1.01	13.45	165	.27	.26	.00	460.
1.01	1.50	22	.01	.00	.01	6.	1.01	13.50	166	.27	.26	.00	463.
1.01	1.55	23	.01	.01	.01	6.	1.01	13.55	167	.27	.26	.00	465.
1.01	2.00	24	.01	.01	.01	7.	1.01	14.00	168	.27	.26	.00	466.
1.01	2.05	25	.01	.01	.01	7.	1.01	14.05	169	.33	.33	.00	470.
1.01	2.10	26	.01	.01	.01	8.	1.01	14.10	170	.33	.33	.00	477.
1.01	2.15	27	.01	.01	.01	8.	1.01	14.15	171	.33	.33	.00	482.
1.01	2.20	28	.01	.01	.01	9.	1.01	14.20	172	.33	.33	.00	512.
1.01	2.25	29	.01	.01	.01	9.	1.01	14.25	173	.33	.33	.00	521.
1.01	2.30	30	.01	.01	.01	10.	1.01	14.30	174	.33	.33	.00	548.
1.01	2.35	31	.01	.01	.01	10.	1.01	14.35	175	.33	.33	.00	560.
1.01	2.40	32	.01	.01	.01	11.	1.01	14.40	176	.33	.33	.00	564.
1.01	2.45	33	.01	.01	.01	11.	1.01	14.45	177	.33	.33	.00	574.
1.01	2.50	34	.01	.01	.01	11.	1.01	14.50	178	.33	.33	.00	579.
1.01	2.55	35	.01	.01	.01	12.	1.01	14.55	179	.33	.33	.00	582.
1.01	3.00	36	.01	.01	.01	12.	1.01	15.00	180	.33	.33	.00	584.
1.01	3.05	37	.01	.01	.01	12.	1.01	15.05	181	.20	.20	.00	581.
1.01	3.10	38	.01	.01	.01	13.	1.01	15.10	182	.40	.40	.00	575.
1.01	3.15	39	.01	.01	.01	13.	1.01	15.15	183	.40	.40	.00	565.
1.01	3.20	40	.01	.01	.01	13.	1.01	15.20	184	.60	.60	.00	583.
1.01	3.25	41	.01	.01	.01	14.	1.01	15.25	185	.71	.70	.00	628.
1.01	3.30	42	.01	.01	.01	14.	1.01	15.30	186	1.71	1.71	.00	743.
1.01	3.35	43	.01	.01	.01	14.	1.01	15.35	187	2.82	2.82	.00	543.
1.01	3.40	44	.01	.01	.01	15.	1.01	15.40	188	1.11	1.11	.00	1381.
1.01	3.45	45	.01	.01	.01	15.	1.01	15.45	189	.71	.70	.00	1803.
1.01	3.50	46	.01	.01	.01	15.	1.01	15.50	190	.60	.60	.00	2060.
1.01	3.55	47	.01	.01	.01	15.	1.01	15.55	191	.40	.40	.00	2095.
1.01	4.00	48	.01	.01	.01	15.	1.01	16.00	192	.40	.40	.00	1937.
1.01	4.05	49	.01	.01	.01	16.	1.01	16.05	193	.31	.31	.00	1674.
1.01	4.10	50	.01	.01	.00	16.	1.01	16.10	194	.31	.31	.00	1404.
1.01	4.15	51	.01	.01	.00	16.	1.01	16.15	195	.31	.31	.00	1183.
1.01	4.20	52	.01	.01	.00	16.	1.01	16.20	196	.31	.31	.00	1005.
1.01	4.25	53	.01	.01	.00	17.	1.01	16.25	197	.31	.31	.00	675.
1.01	4.30	54	.01	.01	.00	17.	1.01	16.30	198	.31	.31	.00	775.
1.01	4.35	55	.01	.01	.00	17.	1.01	16.35	199	.31	.31	.00	710.

Input Data
 Various PMF Events
 Spring Lake Dam
 MO. ID. No. 30725
 B6

1.01	4.30	54	.01	.01	.01	.01	.01	14.	1.01	16.30	194	.31	.31	.00	316.
1.01	4.35	55	.01	.01	.01	.01	.01	14.	1.01	16.35	194	.31	.31	.00	316.
1.01	4.40	56	.01	.01	.01	.01	.01	14.	1.01	16.40	200	.31	.31	.00	316.
1.01	4.45	57	.01	.01	.01	.01	.01	14.	1.01	16.45	201	.31	.31	.00	316.
1.01	4.50	58	.01	.01	.01	.01	.01	14.	1.01	16.50	202	.31	.31	.00	316.
1.01	4.55	59	.01	.01	.01	.01	.01	14.	1.01	16.55	203	.31	.31	.00	316.
1.01	5.00	60	.01	.01	.01	.01	.01	14.	1.01	17.00	204	.31	.31	.00	316.
1.01	5.05	61	.01	.01	.01	.01	.01	14.	1.01	17.05	205	.24	.24	.00	316.
1.01	5.10	62	.01	.01	.01	.01	.01	14.	1.01	17.10	206	.24	.24	.00	316.
1.01	5.15	63	.01	.01	.01	.01	.01	14.	1.01	17.15	207	.24	.24	.00	316.
1.01	5.20	64	.01	.01	.01	.01	.01	14.	1.01	17.20	208	.24	.24	.00	316.
1.01	5.25	65	.01	.01	.01	.01	.01	14.	1.01	17.25	209	.24	.24	.00	316.
1.01	5.30	66	.01	.01	.01	.01	.01	14.	1.01	17.30	210	.24	.24	.00	316.
1.01	5.35	67	.01	.01	.01	.01	.01	14.	1.01	17.35	211	.24	.24	.00	316.
1.01	5.40	68	.01	.01	.01	.01	.01	14.	1.01	17.40	212	.24	.24	.00	316.
1.01	5.45	69	.01	.01	.01	.01	.01	14.	1.01	17.45	213	.24	.24	.00	316.
1.01	5.50	70	.01	.01	.01	.01	.01	14.	1.01	17.50	214	.24	.24	.00	316.
1.01	5.55	71	.01	.01	.01	.01	.01	14.	1.01	17.55	215	.24	.24	.00	316.
1.01	6.00	72	.01	.01	.01	.01	.01	14.	1.01	18.00	216	.24	.24	.00	316.
1.01	6.05	73	.07	.07	.07	.07	.07	24.	1.01	18.05	217	.02	.02	.00	316.
1.01	6.10	74	.07	.07	.07	.07	.07	24.	1.01	18.10	218	.02	.02	.00	316.
1.01	6.15	75	.07	.07	.07	.07	.07	24.	1.01	18.15	219	.02	.02	.00	316.
1.01	6.20	76	.07	.07	.07	.07	.07	24.	1.01	18.20	220	.02	.02	.00	316.
1.01	6.25	77	.07	.07	.07	.07	.07	24.	1.01	18.25	221	.02	.02	.00	316.
1.01	6.30	78	.07	.07	.07	.07	.07	24.	1.01	18.30	222	.02	.02	.00	316.
1.01	6.35	79	.07	.07	.07	.07	.07	24.	1.01	18.35	223	.02	.02	.00	316.
1.01	6.40	80	.07	.07	.07	.07	.07	24.	1.01	18.40	224	.02	.02	.00	316.
1.01	6.45	81	.07	.07	.07	.07	.07	24.	1.01	18.45	225	.02	.02	.00	316.
1.01	6.50	82	.07	.07	.07	.07	.07	24.	1.01	18.50	226	.02	.02	.00	316.
1.01	6.55	83	.07	.07	.07	.07	.07	24.	1.01	18.55	227	.02	.02	.00	316.
1.01	6.60	84	.07	.07	.07	.07	.07	24.	1.01	19.00	228	.02	.02	.00	316.
1.01	7.05	85	.07	.07	.07	.07	.07	24.	1.01	19.05	229	.02	.02	.00	316.
1.01	7.10	86	.07	.07	.07	.07	.07	24.	1.01	19.10	230	.02	.02	.00	316.
1.01	7.15	87	.07	.07	.07	.07	.07	24.	1.01	19.15	231	.02	.02	.00	316.
1.01	7.20	88	.07	.07	.07	.07	.07	24.	1.01	19.20	232	.02	.02	.00	316.
1.01	7.25	89	.07	.07	.07	.07	.07	24.	1.01	19.25	233	.02	.02	.00	316.
1.01	7.30	90	.07	.07	.07	.07	.07	24.	1.01	19.30	234	.02	.02	.00	316.
1.01	7.35	91	.07	.07	.07	.07	.07	24.	1.01	19.35	235	.02	.02	.00	316.
1.01	7.40	92	.07	.07	.07	.07	.07	24.	1.01	19.40	236	.02	.02	.00	316.
1.01	7.45	93	.07	.07	.07	.07	.07	24.	1.01	19.45	237	.02	.02	.00	316.
1.01	7.50	94	.07	.07	.07	.07	.07	24.	1.01	19.50	238	.02	.02	.00	316.
1.01	7.55	95	.07	.07	.07	.07	.07	24.	1.01	19.55	239	.02	.02	.00	316.
1.01	7.60	96	.07	.07	.07	.07	.07	24.	1.01	20.00	240	.02	.02	.00	316.
1.01	7.65	97	.07	.07	.07	.07	.07	24.	1.01	20.05	241	.02	.02	.00	316.

Input Data
Various PMF Events
Spring Lake Dam
MO. ID. No. 30725
B7

1.01	6.00	55	.07	.06	.00	104.	1.01	19.55	239	.02	.02	.00	.00
1.01	5.00	56	.07	.06	.00	104.	1.01	20.00	260	.02	.02	.00	.00
1.01	4.50	57	.07	.06	.00	104.	1.01	20.05	241	.02	.02	.00	.00
1.01	4.10	58	.07	.06	.00	104.	1.01	20.10	242	.02	.02	.00	.00
1.01	3.15	59	.07	.06	.00	104.	1.01	20.15	243	.02	.02	.00	.00
1.01	3.20	60	.07	.06	.00	105.	1.01	20.20	244	.02	.02	.00	.00
1.01	8.25	61	.07	.06	.00	104.	1.01	20.25	245	.02	.02	.00	.00
1.01	4.30	62	.07	.06	.00	104.	1.01	20.30	246	.02	.02	.00	.00
1.01	5.35	63	.07	.06	.00	104.	1.01	20.35	247	.02	.02	.00	.00
1.01	8.40	64	.07	.06	.00	104.	1.01	20.40	248	.02	.02	.00	.00
1.01	5.45	65	.07	.06	.00	104.	1.01	20.45	249	.02	.02	.00	.00
1.01	8.50	66	.07	.06	.00	110.	1.01	20.50	250	.02	.02	.00	.00
1.01	4.55	67	.07	.06	.00	110.	1.01	20.55	251	.02	.02	.00	.00
1.01	4.00	68	.07	.06	.00	110.	1.01	21.00	252	.02	.02	.00	.00
1.01	4.05	69	.07	.06	.00	110.	1.01	21.05	253	.02	.02	.00	.00
1.01	4.10	70	.07	.06	.00	110.	1.01	21.10	254	.02	.02	.00	.00
1.01	4.15	71	.07	.06	.00	111.	1.01	21.15	255	.02	.02	.00	.00
1.01	4.20	72	.07	.06	.00	111.	1.01	21.20	256	.02	.02	.00	.00
1.01	4.25	73	.07	.06	.00	111.	1.01	21.25	257	.02	.02	.00	.00
1.01	4.30	74	.07	.06	.00	111.	1.01	21.30	258	.02	.02	.00	.00
1.01	4.35	75	.07	.06	.00	111.	1.01	21.35	259	.02	.02	.00	.00
1.01	4.40	76	.07	.06	.00	111.	1.01	21.40	260	.02	.02	.00	.00
1.01	4.45	77	.07	.06	.00	111.	1.01	21.45	261	.02	.02	.00	.00
1.01	4.50	78	.07	.06	.00	112.	1.01	21.50	262	.02	.02	.00	.00
1.01	4.55	79	.07	.06	.00	112.	1.01	21.55	263	.02	.02	.00	.00
1.01	10.00	80	.07	.06	.00	112.	1.01	22.00	264	.02	.02	.00	.00
1.01	10.05	81	.07	.06	.00	112.	1.01	22.05	265	.02	.02	.00	.00
1.01	10.10	82	.07	.06	.00	112.	1.01	22.10	266	.02	.02	.00	.00
1.01	10.15	83	.07	.06	.00	112.	1.01	22.15	267	.02	.02	.00	.00
1.01	10.20	84	.07	.06	.00	112.	1.01	22.20	268	.02	.02	.00	.00
1.01	10.25	85	.07	.06	.00	112.	1.01	22.25	269	.02	.02	.00	.00
1.01	10.30	86	.07	.06	.00	112.	1.01	22.30	270	.02	.02	.00	.00
1.01	10.35	87	.07	.06	.00	112.	1.01	22.35	271	.02	.02	.00	.00
1.01	10.40	88	.07	.06	.00	113.	1.01	22.40	272	.02	.02	.00	.00
1.01	10.45	89	.07	.06	.00	113.	1.01	22.45	273	.02	.02	.00	.00
1.01	10.50	90	.07	.06	.00	113.	1.01	22.50	274	.02	.02	.00	.00
1.01	10.55	91	.07	.06	.00	113.	1.01	22.55	275	.02	.02	.00	.00
1.01	11.00	92	.07	.06	.00	113.	1.01	23.00	276	.02	.02	.00	.00
1.01	11.05	93	.07	.06	.00	113.	1.01	23.05	277	.02	.02	.00	.00
1.01	11.10	94	.07	.06	.00	113.	1.01	23.10	278	.02	.02	.00	.00
1.01	11.15	95	.07	.06	.00	113.	1.01	23.15	279	.02	.02	.00	.00
1.01	11.20	96	.07	.06	.00	113.	1.01	23.20	280	.02	.02	.00	.00
1.01	11.25	97	.07	.06	.00	113.	1.01	23.25	281	.02	.02	.00	.00
1.01	11.30	98	.07	.06	.00	113.	1.01	23.30	282	.02	.02	.00	.00
1.01	11.35	99	.07	.06	.00	113.	1.01	23.35	283	.02	.02	.00	.00
1.01	11.40	100	.07	.06	.00	113.	1.01	23.40	284	.02	.02	.00	.00
1.01	11.45	101	.07	.06	.00	113.	1.01	23.45	285	.02	.02	.00	.00
1.01	11.50	102	.07	.06	.00	114.	1.01	23.50	286	.02	.02	.00	.00
1.01	11.55	103	.07	.06	.00	114.	1.01	23.55	287	.02	.02	.00	.00
1.01	12.00	104	.07	.06	.00	114.	1.01	23.60	288	.02	.02	.00	.00

SUM 33.80 32.44 52 23.10 145.20

Input Data
Various PMF Events
Spring Lake Dam
MO. ID. No. 30725
B8

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN RATIO 1	RATIO 2
			.50	1.00

HYDROGRAPH AT	U-1A	.23	1	1045	2054
		.601	1	24.5M31	54.1P10
MODIFIED TO	DAP	.23	1	430	2011
		.601	1	26.3M31	56.4P10

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	RATIO OF PMF	ELEVATION STORAGE	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-11	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TOP OF DAM	TIME OF FAILURE HOURS
	.50	893.10	1.05	114	430	3.04	894.50	C
	1.00	92	1.66	124	2011	5.43	107	C
		18					252	

Output Summary
 Various PMF Events
 Spring Lake Dam
 MO. ID. No. 30725
 B9

 FLOOD HYDROGRAPH PACKAGE (HFC-1)
 DAM SAFETY DIVISION JULY 1979
 LAST MODIFICATION 21 APR 80

RUN DATE IS SEP 80
 TIME IS 11:55:40

DAM NO. 30725 - SPRING LAKE, WASHINGTON COUNTY, MISSOURI.
 MULLWARD-CLYDE CONSULTANTS, HOUSTON JOH 7904009.
 PROBABLE MAXIMUM FLOODS (PPF) ANALYSIS.

NO	NPR	NPM	IDAY	JOM SPECIFICATION				IPLY	IPPT	NSTAN
				IMW	IPM	MTVC	TRCF			
0.	0	5	-0	-0	-0	-0	-0	-0	5	-0
0.	0	5	0000	00	00	00	00	00	5	-0
065.	970.	480.	480.	483.	485.	480.	480.	480.	5	-0
CMTL SPWID CUOM -0. -0. -0. -0. -0. -0. -0. -0. -0. -0. -0. 983.1 -0. -0. -0. -0. -0. -0. -0. -0. -0. -0.										
LAF DATA TOPFL CUCO EXPD CAPWIC 944.5 2.6 1.5 -0.										

PEAK OUTFLOW IS 199. AT TIME 16.25 HOURS
 PEAK OUTFLOW IS 231. AT TIME 16.25 HOURS
 PEAK OUTFLOW IS 264. AT TIME 15.17 HOURS
 PEAK OUTFLOW IS 300. AT TIME 15.17 HOURS

Input Data
 Various PMF Events
 Spring Lake Dam
 MO. ID. No. 30725
 B10

PLAN FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

RATIO 1 RATIO 2 RATIO 3 RATIO 4

.16 .20 .22

PLAN RATIO 1 RATIO 2 RATIO 3 RATIO 4

.16 .20 .22

PLAN RATIO 1 RATIO 2 RATIO 3 RATIO 4

.16 .20 .22

PLAN RATIO 1 RATIO 2 RATIO 3 RATIO 4

.16 .20 .22

PLAN RATIO 1 RATIO 2 RATIO 3 RATIO 4

.16 .20 .22

HYDROGRAPH AT

Q-1M

Q-1M

Q-1M

Q-1M

Q-1M

Q-1M

Q-1M

Q-1M

Q-1M

Q-1M

Q-1M

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Q-1M

Q-1M

Q-1M

Q-1M

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Q-1M

Q-1M

SUMMARY OF DAM SAFETY ANALYSIS

TOP OF DAM
 884.50
 187.
 252.

SPILLWAY CRIST

883.10

42.

1M.

1M.

1M.

1M.

1M.

1M.

1M.

TOP OF DAM

884.50

187.

252.

1M.

1M.

1M.

1M.

1M.

1M.

1M.

TYPE OF
 FAILURE
 MECHANISM

TYPE OF
 FAILURE
 MECHANISM

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 MECHANISM

Output Summary
 Various PMF Events
 Spring Lake Dam
 MO. ID. No. 30725
 B11